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Pyrolysed carbon microelectrode for Environmental and Life Science Applications

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Introduction

Fabrication, characterisation and testing of a highly efficient and simple electrochemical cell/batch system, with pyrolysed carbon as the working electrode is presented. The pyrolysed carbon is characterized by Raman, 4-point measurement, CV and EIS[1]. Electrode design was optimized, evaluating the effect of lead width and carbon thickness.

Fabrication of Carbon4Bio chips

An three electrode electrochemical cell(Carbon4Bio) was fabricated, with pyrolysed carbon as working and counter electrodes and Au as pseudo-reference electrodes.

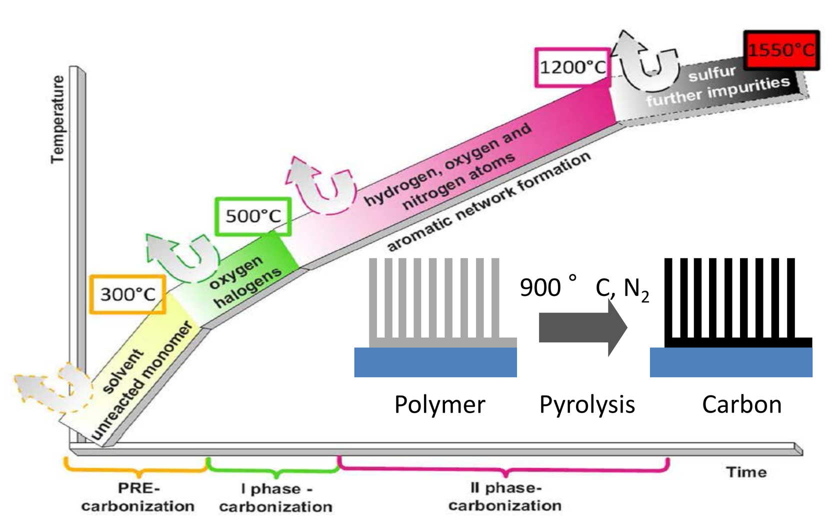


Figure 1: Sematic of prolysis process with multi-step carbonization process taking place during pyrolysis[2]

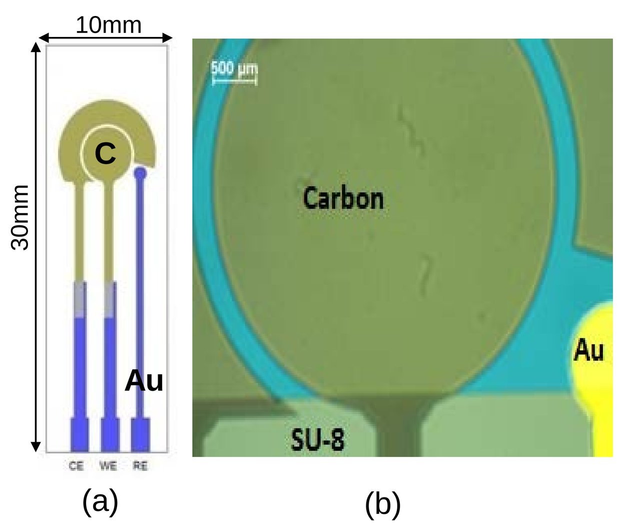


Figure 2: Top view of C4B chips (a) schematic (b) Optical microscopy images showing WE (Carbon), RE (Au), passivation layer (SU-8)

Fabrication of MagClamp systems

For the electrochemical measurements a batch system with self-aligning magnetic clamping (MagClamp) was developed.

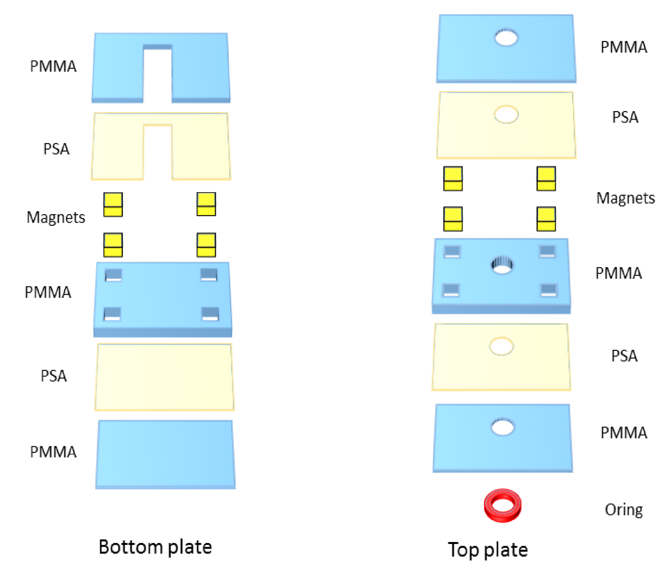


Figure 3: 3D schematic of MagClamp assemble showing differnt layers

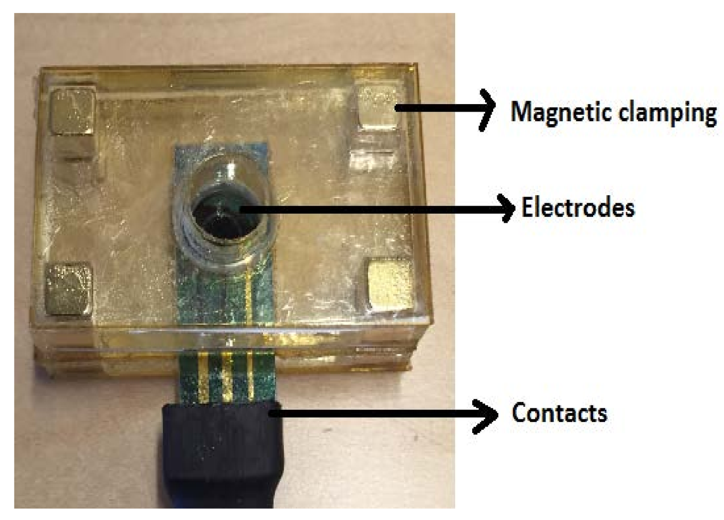


Figure 4: Top view of the overall batch system with intergrated C4B chip.

Carbon lead width optimization

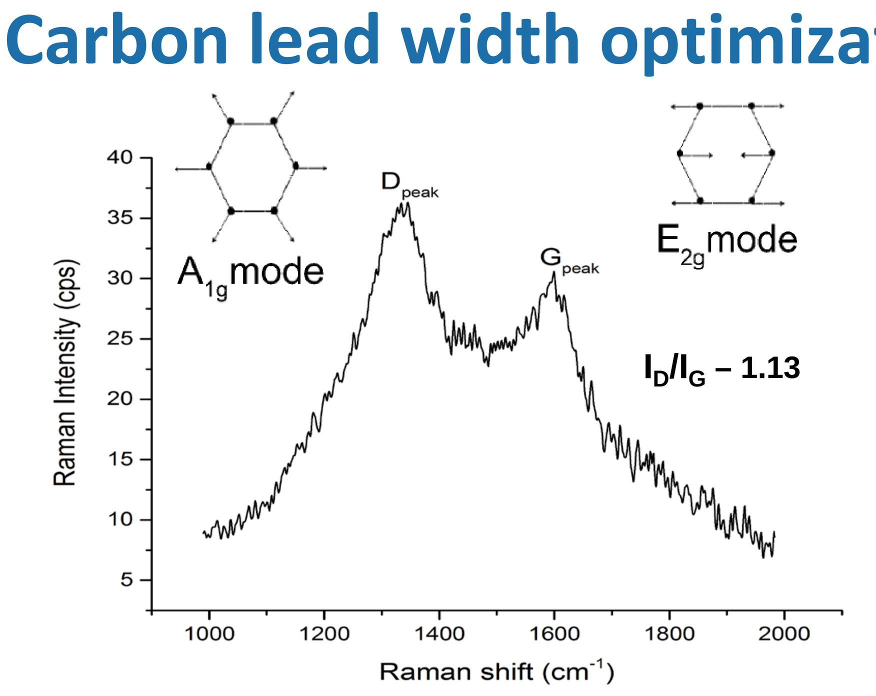


Figure 5: Raman spectra of the pyrolysed carbon electrode with thickness(t), 624nm with distinct D and G peaks that are characteristic for pyrolysed carbon material[3]

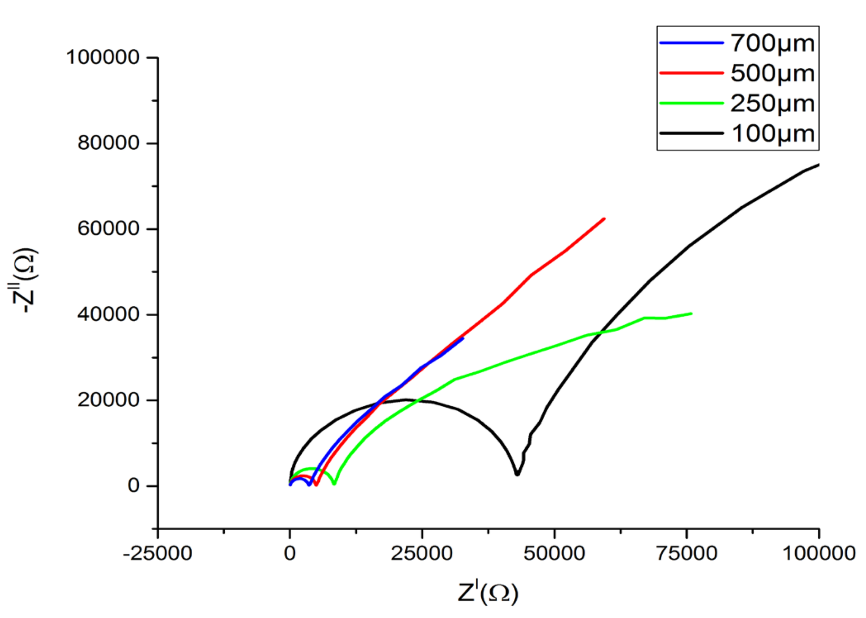


Figure 6: Impedance spectroscopy between carbon (t - 624nm) WE and CE in PBS, radius of the capacitive semicircle decreases with wider leads

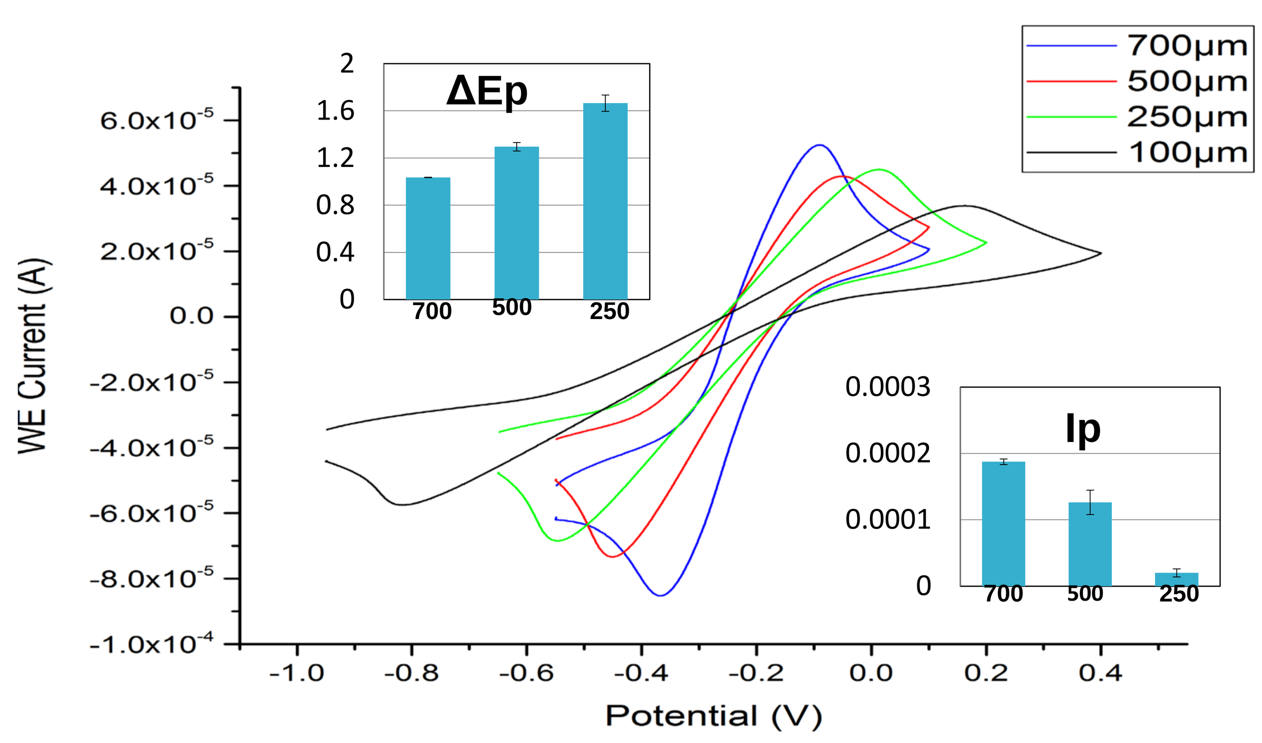
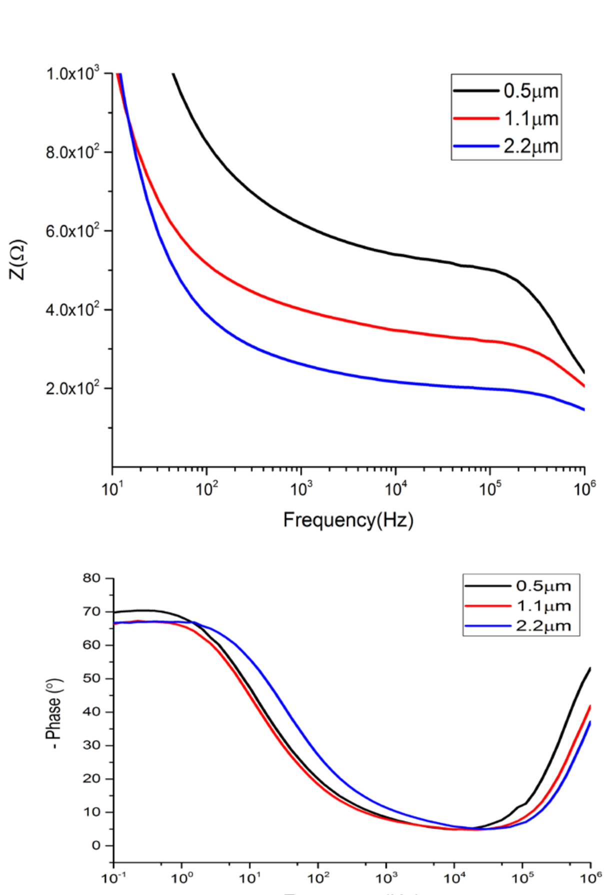


Figure 7: Cyclic voltammetry using 10M ferri-ferrocyanide as redox probe shows that as the width of the contact lead increases the peak potential difference (ΔE_p) decreases and the peak current (Ip) increases. Thickness of carbon electrode is 624nm .

Carbon thickness characterisation



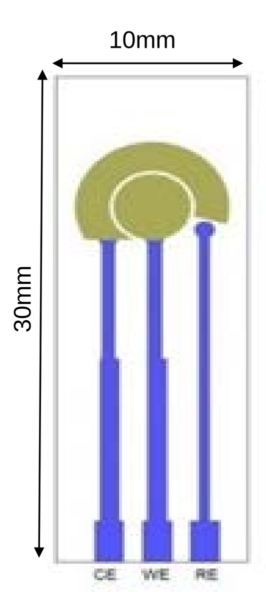


Figure 8: Impedance of carbon electrode (lead width – 700µm) with different thickness in PBS. As the thickness of carbon increases, the overll resistance decreaeses

Comparison of C4B and Dropsens carbon electrodes

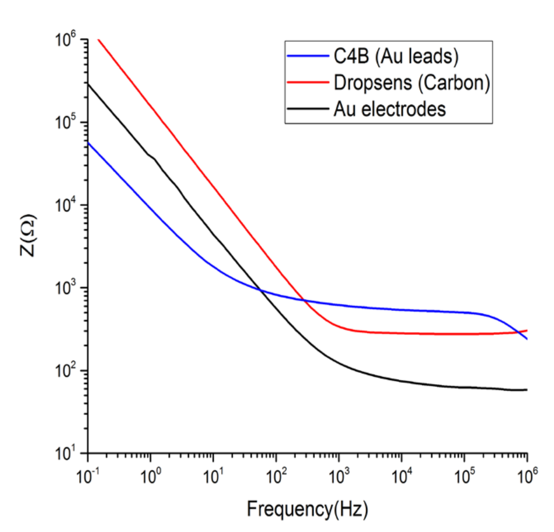


Figure 9: Comparsion of impedance magnitude. Au electrodes shows the least impedance, where as C4B chips with Au as leads shows the maximum impedance

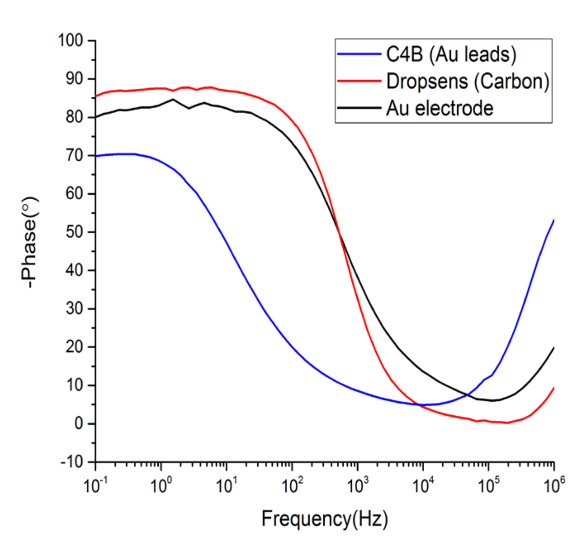


Figure 10: Comparsion of impedance phase of Dropsens electrodes.C4B electrodes and Au electrodes.

Yeast on C4B

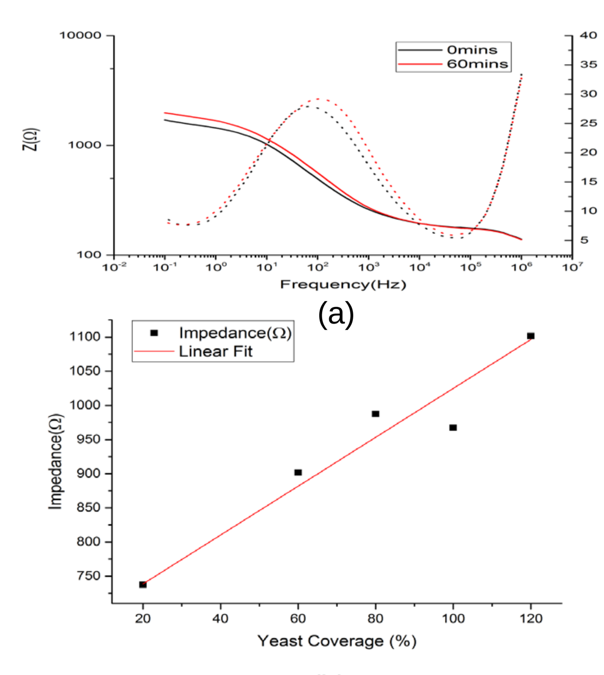
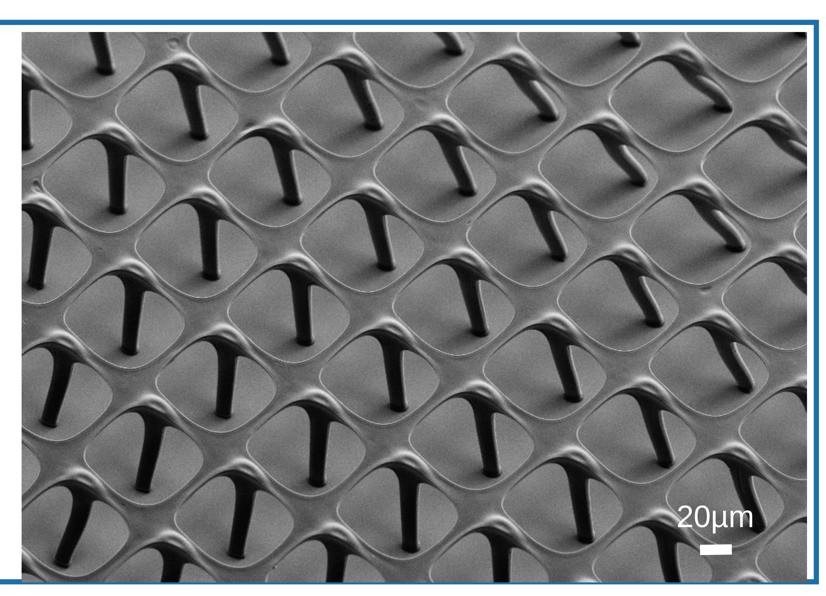


Figure 11: (a) Impedance measured at 0 and 60 mins at 100 % coverage and (b) Impedance between WE and CE measuered at 10Hz increases as the yeast coverage increases.

Conclusion and Outlook

- **As the width and thickness of pyrolysed carbon increases, the overall resistance decreases and the increases the sensitivity of the C4B chips**
- **C4B chips with Au contact leads increases the sensitivity**
- **EIS studies on yeast shows pyrolysed carbon as a potential electrode for tissue engineering**
- **Exploring more application for pyrolysed carbon (C4B)**



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[2] Wang, C., Taherabadi, L. H. & Madou, M. J. A novel method for the fabrication of high-aspect ratio C-MEMS structures. Journal of Microelectromechanical Systems 14, 348–358 (2005).
[3] Ferrari, A. & Robertson, J. Interpretation of Raman spectra of disordered and amorphous carbon, Physical Review B 61, 14095–14107 (2000).

Acknowledgments

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